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ALTITUDE WARNING SIGNAL SYSTEM EVALUATION.(U)
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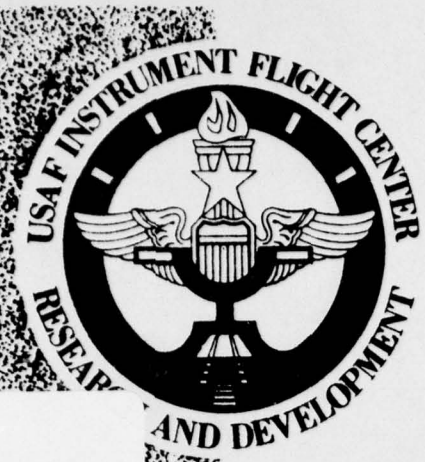

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USAFIFC TE 76-1

ALTITUDE WARNING SIGNAL SYSTEM EVALUATION

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APRIL 1977

FINAL REPORT

USAF INSTRUMENT FLIGHT CENTER
Randolph AFB, Texas 78148

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The Research and Development Division, USAF Instrument Flight Center (USAFIFC/RD) conducted a pilot factors evaluation of the Harowe Altitude Warning Signal System (AWSS) to determine its acceptability for use in Air Force aircraft. The system has the primary function of assisting pilots in attaining and maintaining assigned or desired (command) altitudes. A secondary function, the approach mode, was incorporated in the AWSS to examine the concept of altitude warning during landing approaches. Thirteen sorties were flown in an NT-38 Talon. Subject pilots were selected from IFC personnel. —> next page

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The overall concept and operation was found to be acceptable by half of the subject pilots. Half of the subject pilots felt the information provided by the system did not justify the increased workload.

The normal and approach modes of operation were found to be acceptable in concept, operation, and accuracy.

The system in its present configuration is not acceptable for installation in trainer and single place aircraft due to the unacceptable increase in cockpit workload.

PREFACE

This technical report presents the findings of project TE 76-1 conducted by the USAF Instrument Flight Center, Research and Development Division (USAFIFC/RD) at the request of the Aeronautical Systems Division, Flight Instruments Division (ASD/ENAID).

Flying activities on the project were conducted at Randolph AFB TX. Human factors engineering support were performed by Mr. Gerald C. Armstrong and Dr. Dolores M. Tyler, USAFIFC Research Psychologists; systems engineering support was performed by Capt William B. Orcutt and Mr. George A. Rex, USAFIFC Aerospace Engineers, installation of the project equipment was performed by Mr. Orrin C. Kopff and Mr. Raoul G. Canamar, USAFIFC Avionics Technicians; and secretarial support was performed by Mrs. Shirley W. Pauley.

This technical report has been reviewed and approved.

John H Carpenter

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INTRODUCTION

The USAF Instrument Flight Center, Research and Development Division (USAFIFC/RD) was requested by the Aeronautical Systems Division (ASD/ENAID) to conduct a pilot factor flight evaluation of the Harowe Altitude Warning Signal System (AWSS). This project was follow-on to a previous evaluation conducted on an earlier Harowe System (Harowe AWS, TE 74-2) by USAFIFC/RD.

The AWSS has as its primary function, that of assisting pilots in attaining and maintaining assigned or desired (command) altitudes. Visually alerting the pilot at two preselected altitudes relative to the command altitude assists him in attaining his desired altitude. Maintenance of a command altitude is enhanced by visual and aural signals alerting the pilot that the aircraft has deviated from the command altitude by a preselected altitude tolerance.

A secondary function (approach mode) has been incorporated in the AWSS to expand the concept of altitude warning for landing approaches. In this mode the system alerts the pilot in a slightly different manner than in the primary mode. The difference incorporated the addition of an alerting function as the aircraft reaches decision height altitude.

TEST OBJECTIVES

General: To conduct in-flight pilot factors evaluations of the Harowe Altitude Warning Signal System which includes the following:

a. Determine the capabilities of the AWSS for aiding pilots in leveling at, and maintaining desired altitudes.

b. Determine the suitability and operability of the approach mode concept of the AWSS.

c. Obtain a cross-section of pilot opinion regarding the performance of the AWSS under mission oriented flight conditions.

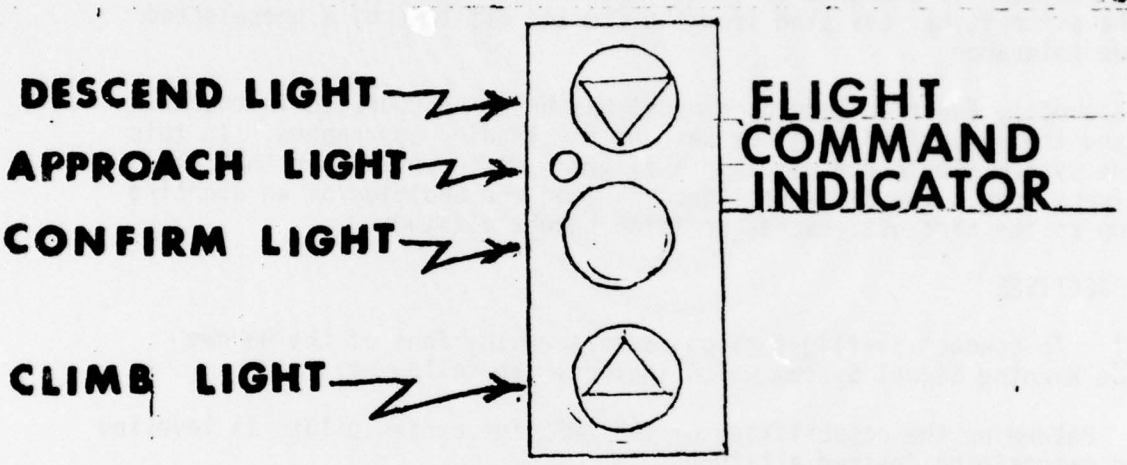
Specific:

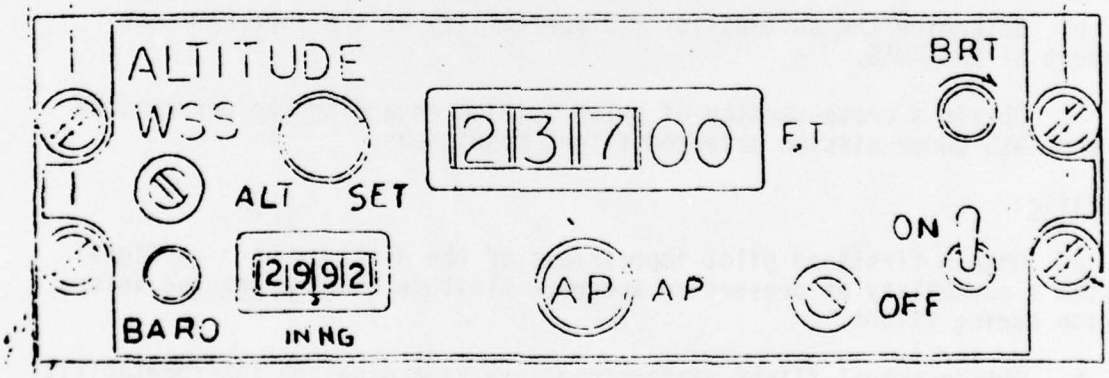
a. Obtain firsthand pilot impressions of the Altitude Warning Signal System's capability of presenting accurate altitude command/warning information during flight.

b. Obtain actual flight performance data regarding the interpretability of the AWSS information for achieving and holding command altitude at varied ascent and descent rates and varied trigger level.

c. Obtain in-flight pilot opinions regarding the usefulness and precision of the approach mode concept.

d. Obtain pilot suggestions and recommendations concerning the human engineering features of the systems; i.e., control operations, procedures, sequencing, color, shape, etc.





AWSS control panel

(FIGURE 1)

ALTITUDE WARNING SYSTEM

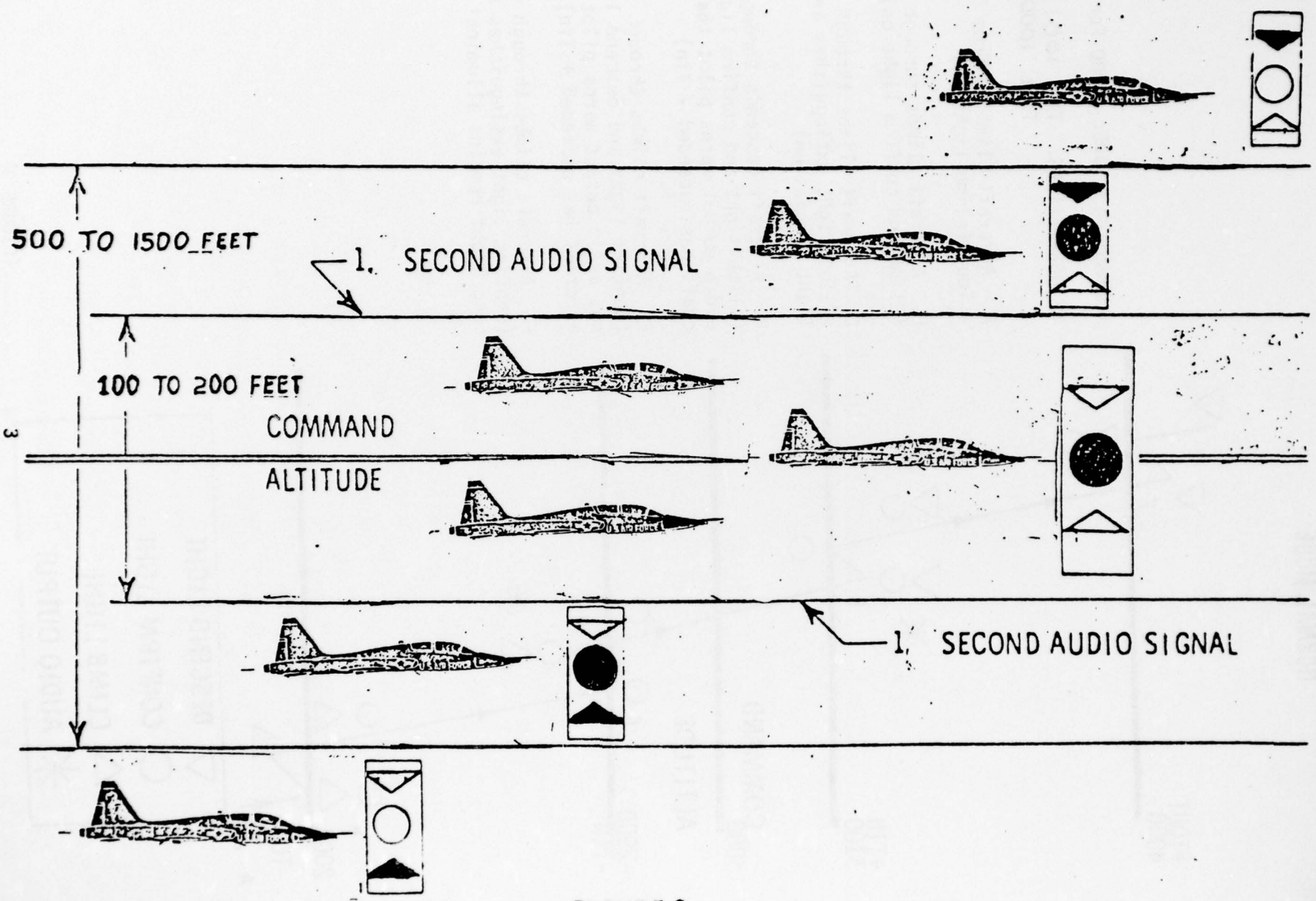
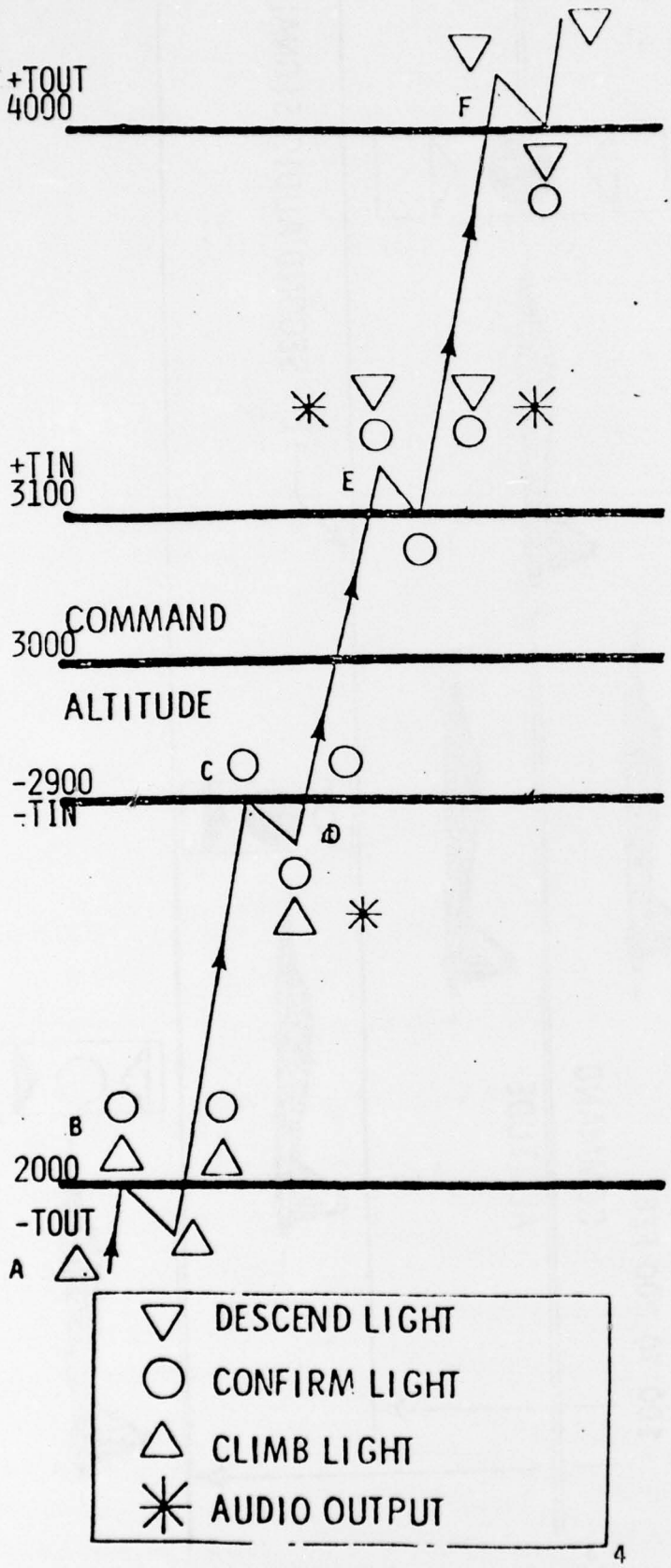


FIGURE 2

NORMAL MODE



COMMAND ALTITUDE: 3000 Feet

TRIGGER LEVELS: Tin 100 Feet
Tout 1000 Feet

A. Aircraft climbing from below - Tout (climb light on)

B. Aircraft climbs through - Tout (Climb and confirm light on)

C. Aircraft climbs through - Tin (Climb light extinguishes and confirm light remains on)

D. Aircraft descends through - Tin (climb light and confirm light on, audio output warns pilot that aircraft has exceeded - Tin)

E. Aircraft climbs through + Tin (Confirm light and descend light on, audio output warns pilot that aircraft has exceeded + Tin)

F. Aircraft climbs through +Tout (confirm light extinguishes and descend light remains illuminated)

(FIGURE 3)

e. Obtain pilot suggestions and recommendations for any changes, deletions, or additions to the AWSS.

DESCRIPTION OF TEST ITEM

The AWSS has three main components. These are a console or panel-mounted central control unit and two remote display units. The control unit contains all necessary electronics and controls. The remote display units contain the command indicator lights and the approach light. The Harowe AWSS (figure 1) is designed to operate in parallel with mode "C" circuits of existing IFF/SIF (APZ-64, APZ-72, KY-532A, KY-533A) transponders. The AWSS is designed to operate with the AIMS digital altitude reporting signal plus the AIMS syncro signal. The AWSS will function regardless of whether or not the transponder is operative.

The command indicator display consists of triangular shaped climb and descent lights, and a round confirm light. Command altitude is manually set by the pilot. There are two trigger levels, inner (T_{IN}) and outer (T_{OUT}), which establish alerting zones referenced to the selected command altitude. Specific combinations of lights and aural tones are triggered when transiting each alerting zone (figure 2). Trigger level settings were accomplished by the project crew prior to flight via adjustments under a plate in the rear of the control unit. T_{IN} had two settings of 100 to 200 feet. T_{OUT} had settings of 500, 1000, and 1500 feet. Both inner and outer trigger levels were set, using the foregoing pre-calibrated increments with respect to the command altitude. A one-second audio output occurred when the aircraft deviated from the inner zone, and every 20 seconds thereafter. A detailed schema of the operation is shown in figure 3.

The controls on the AWSS control unit include a command altitude setting knob, barometric pressure setting knob, approach mode button, and an on-off switch.

a. Any command altitude between 0 and 49,900 feet may be set by means of the command altitude setting knob. The command altitude that is set will be displayed on a three drum counter in 100-foot increments.

b. The barometric pressure setting is displayed on a four-digit counter with a range from 28.00 to 30.99. The pressure setting must be reset each time there is a change in altimeter setting.

c. The approach mode of operation is activated by a push button switch marked AP. When the light located in the AP switch, and the blue light located on the remote display unit are illuminated, the AWSS is operating in the approach mode. The details of operation in this mode are discussed in a subsequent paragraph.

d. The lights on the remote display unit automatically reset when the aircraft deviates from the reference command altitude and passes through the inner trigger level.

e. The on-off toggle switch controls the electrical power for excitation of the AWSS.

The approach mode has been incorporated in the AWSS to expand the concept of altitude warning for landing. The approach mode may only be selected when the aircraft's actual altitude is greater than the command altitude. When the AP button is depressed, the AP light on the control panel illuminates, the blue light on the remote display unit illuminates, and the descent and confirm lights extinguish. When the aircraft altitude reaches a value within the inner trigger level altitude, the climb and descent lights illuminate. When the aircraft altitude equals the command altitude, the lights on the remote display unit extinguish, and there is one-second audio output signal. The AWSS, then, reverts to the normal mode of operation.

TEST METHODOLOGY

Thirteen subject pilots were selected from the Instrument Flight Center, Instrument Pilot Instructor School students, and other T-38 qualified pilots. They were requested to complete a round robin flight profile for the evaluation. Data included subjective commentary from qualified T-38 pilots, and pilots TDY to the USAFIFC who were qualified in various Air Force aircraft.

The test sorties were flown on navigation missions both under IMC & VMC conditions to provide exposure to the AWSS in a normal operational situation. This provided high/low altitude exposure, and an opportunity for precision and non-precision approaches in an operational environment. The flight profiles were purposely made flexible, and were accomplished in a manner so as to require maximum use of the AWSS.

The following flight profiles were used:

a. Takeoff, climb, and intermediate level off (command level off altitude set prior to takeoff).

b. Climb to cruise altitude (command cruise altitude set in climb).

c. Cruise (climbs and descents as allowed by Air Traffic Control to determine accuracy of trigger levels).

d. Penetration/enroute descent (command altitude set for intermediate level off).

e. Multiple approaches, fuel and traffic permitting (AWSS used in normal mode), for traffic patterns altitudes and non-precision approaches and in the approach mode for precision approaches.

Preflight:

In addition to the normal preflight mission briefing, the project pilot conducted a thorough preflight test system briefing for each subject pilot. A standardized briefing guide was used to introduce each subject pilot to the pilot factors evaluation concept, the test equipment, and the test objectives.

The subject pilots who were not current in the T-38 aircraft were given a comprehensive briefing on the T-38 front cockpit. This briefing included identification of the major or critical items and components in the front cockpit which were not available in the rear cockpit.

DATA COLLECTION

Each subject pilot was thoroughly debriefed following the test sorties, and immediately filled out the appropriate portion of the questionnaire. All pertinent verbal comments made during debriefings were recorded by the project pilot and a transcript was attached to the subject's completed questionnaire. In flight, the project pilot recorded his observations of system accuracy, the subject's comments, and overall commentary regarding subject pilot and system performance.

RESULTS AND DISCUSSION

The AWSS evaluation was accomplished to evaluate the changes and improvements made on a Harowe Altitude Warning System. The system was evaluated by USAFIFC/RD in 1974. The findings of the previous evaluation are summarized in IFC Report TR 74-7.

During the current evaluation, six of the thirteen subject pilots considered the Harowe AWSS acceptable for installation in Air Force aircraft in its present configuration. Those who thought it was not acceptable felt that the information provided by the system did not justify the increase in work load. Ninety two percent of the subject pilots believed the concept of an altitude warning system warranted further development. Seventy seven percent of the subject pilots felt that the Harowe AWSS reduced the possibility of altitude misinterpretation, and 62% reported it reduced the possibility of misreading the altimeter. Generally, subject pilots believed that the AWSS served more as a cueing device or reminder to cross-check the altimeter. Sixty nine percent of the subject pilots stated that the AWSS did not increase their precision in maintaining command altitude, while 54% said that it made no difference in their confidence while maintaining command altitude. The majority of the subject pilots considered themselves capable of maintaining an altitude within 200 feet; however, six of the thirteed pilots reported that their confidence in maintaining an altitude was increased with the system. Using the AWSS, they felt their attention could be diverted from the altimeter for longer periods without fear of exceeding altitude restrictions.

Normal Mode

Twelve of the thirteen subject pilots agreed that two trigger levels were adequate for the profiles flown. The other subject pilot felt there was a need for separate trigger levels for approaches.

Having the capability of changing trigger levels in flight was considered necessary by 54% of the pilots. They felt that different phases of flight required different altitude tolerances and that the AWSS should have trigger level change flexibility. However, one of the pilots

felt that having changeable trigger levels would increase the change of error in setting and would therefore increase the pilot's work load. At least half of the subject pilots felt a toggle switch for preset trigger levels would be preferable to the present system.

The test sorties were flown with an inner trigger level of 200 feet, and an outer trigger level of 1000 feet. These trigger levels were found acceptable by the majority of the subject pilots. The span in feet between the inner and cuter trigger levels was considered acceptable by 84% of the pilots. When asked what trigger levels were considered most suitable for climbs and descents, the majority of the subject pilots responded that 500 feet for the outer and 200 feet for the inner trigger level would be the most acceptable. For cruise type conditions, 200 feet for both the outer and inner levels was felt to be optimum. A trigger level of 100 feet was felt to be more suitable for approaches than the 200 feet level.

The sequence of operation for the normal mode was considered satisfactory by 92% of the subject pilots. When asked which signal alerted them first on exceeding the inner trigger level, all of the subject pilots stated that it was the audio signal. Intensity and duration of the warning tone was considered acceptable by 64% of the subject pilots. Eighty five percent of the pilots considered the pitch of the auditory tone acceptable. All of the subject pilots stated that the warning tone did not interfere with voice communications. Six of the pilots felt that the warning tone became distracting in the VFR traffic pattern after several minutes. They felt some type of warning tone cut-out should be included to remove the traffic patter distraction.

The size, shape, and color of the lights on the remote display unit were considered satisfactory by 90% of the subject pilots. One problem noted was that the remote indicators resembled an angle of attach indexer used in many Air Force aircraft and could lead to possible problems of confusion between the two. The size of the remote indicators was considered acceptable by all of the pilots. For this evaluation the remote indicators were located on each side of the glare shield. Fifty four percent of the pilots considered this location unsatisfactory because they felt it placed them too far to the side to be in the normal field of view. Generally, the pilots felt the indicator lights should be positioned closer to the ADI as this is where the pilot's attention is normally concentrated. One hundred percent of the pilots reported that the brightness of the remote indicator was unacceptable. The indicators were easily washed out in high ambient light conditions. This was especially true for the green confirm light.

Command altitude and baro setting could be easily read as reported by 77% of the pilots. Sixty two percent of the pilots reported that the command altitude could be reset quickly enough for all in-flight maneuvers. Several subject pilots felt a slew switch would be an added value for setting command altitude. Another pilot felt a click stop at each 50-foot altitude would be helpful in setting command altitude. Thirty eight percent of the subject pilots experienced some difficulty in resetting the command altitude, especially under high workload conditions.

Requiring the additional baro setting for the AWSS was considered an acceptable increase in workload by 54% of the subject pilots. There was a common tendency by the pilots to forget the AWSS baro setting when setting the standard altimeter. Due to the flight characteristics of the T-38 and the flight profile used for this evaluation, the baro setting was required to be reset frequently. This was due to the aircraft passing through the altitude transition level (baro setting 29.92) during numerous occasions throughout the flight profile. One pilot suggested incorporating a transition level switch to automatically set the 29.92 setting into the system when the switch is thrown.

Approach Mode

Ninety two percent of the subject pilots believed that the Approach Mode was a worthwhile concept which warranted further development. Seventy percent of the subject pilots felt the approach mode actually increased their confidence during approaches. The accuracy of the system was considered excellent by the majority of the subject pilots. The subject pilots felt their work load and stress of flying an approach in extremely low weather conditions was greatly reduced by having the approach mode of the altitude warning system in operation.

The sequence of operation for the approach mode was considered satisfactory by 77% of the subject pilots. The majority of the subject pilots stated that they were alerted by the tone rather than the remote indicator lights on approaching DH. Again, the subject pilots felt the light level of the remote indicators was too weak to be compatible with all ambient light conditions. Fifty seven percent of the subject pilots felt the intensity of the blue approach light was too weak to be visable during normal day lighting conditions. Several subject pilots suggested that the remote indicator lights be placed closer to the ADI where they would be in the pilot's primary field of view while flying instrument approaches.

The utility of the Harowe Altitude Warning Signal System was also investigated in the overhead traffic pattern. Only one subject pilot felt that his confidence and precision was increased during the overhead traffic patterns using the AWSS. The majority of the pilots found the warning tone to be distracting during the final turn to landing when command altitude remained set to traffic pattern altitude. Only one subject pilot felt that the system aided in maintaining overhead pattern altitude. The same foregoing comments applied generally to the AWSS used in the traffic pattern at night. Although the remote indicators could be seen better at night due to the lower ambient light conditions, they tended to be somewhat more distracting. Due to the aforementioned distractions, 54% of the subject pilots felt the approach mode was unacceptable for use in the traffic pattern. The pilots preferring the approach mode felt that its operation was less distracting because there were no more lights or warning tones to distract them after they had passed the traffic pattern altitude.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

a. The subject pilots were more or less equally divided in their opinions as to the operational acceptability of the AWSS (as configured and flight

evaluated). Half of the subject pilots felt that the information provided by the AWSS did not justify the additional workload. The other half felt that, in a crew type aircraft, the system would be acceptable.

b. The normal mode of operations was acceptable for climb, cruise, and descents. The trigger levels were found to be highly accurate.

c. The approach mode of operation was acceptable in both sequence and accuracy of trigger levels.

d. The AWSS in its present configuration did not lend itself to efficient use in the VFR traffic pattern.

Recommendations:

a. A switch should be placed on the control head to convert the baro setting to 29.92.

b. The brightness of the remote indicator light should be increased.

c. The remote indicator lights should be positioned on the instrument panel in close proximity to the primary flight instruments. This would allow them to be integrated into the normal instrument cross-check.

d. The remote indicator lights display format should be changed. At present they could be easily mistaken for the standard AOA indexer.

e. The command altitude set knob should have detents at each 50-foot increment to facilitate setting decision heights and minimum descent altitudes more accurately.

f. The control head should be positioned in a location that can be easily seen and reached by the pilot.

ALTITUDE WARNING SIGNAL SYSTEM OPERATIONAL USAGE

SUBJECT PILOT QUESTIONNAIRE

Date_____Flight Time_____Day_____Night_____IMC_____VMC_____

Flight No._____Local_____Cross Country_____

NAME_____Rank_____SSAN_____

Organization Address_____Duty Phone_____

1. Please indicate your present Command Assignment.

___ATC ___MAC ___SAC ___TAC ___ADC ___Other (Specify)_____

2. Indicate your present flight qualifications.

___Instructor Pilot ___Flight Check Pilot ___Copilot

___Flight Leader ___Element Leader ___Aircraft Commander

3. Indicate your flight experience.

Total flying time as a pilot (Approx) _____

Total Instructor Pilot time (Approx) _____

Total actual instrument time (Approx) _____

Total simulated instrument time (Approx) _____

4. What trigger levels were used for this flight?

T_{out}_____ T_{in}_____

_____ _____

_____ _____

5. Did the AWSS reduce the possibility of misinterpreting/misreading the altimeter?

	Misinterpreting	Misreading
Yes		
No		

Please explain.

6. What was your confidence/precision in maintaining command altitude with the AWSS as compared with the altimeter alone?

	Confidence	Precision
Greater		
Lesser		
No Difference		

Please explain.

7. If properly set, are two trigger levels adequate?

Yes_____ No_____

If no, how many?

8. Should there be a capability of changing trigger levels in flight?

Yes_____ No_____

Why, or why not?

9. Would a toggle switch for preset trigger levels be preferable to the present system?

Yes_____ No_____

10. Was the sequence of indicator operation satisfactory?

Yes_____ No_____

If no, please explain why, and what it should be

11. If you exceeded the inner trigger level, which alerted you first?

Audio Signal_____ Visual Signal_____ Both Simultaneously_____

12. The audio warning tone provides secondary warnings every 20 seconds after the initial alert. Is this a good feature?

Yes_____ No_____

If no, why not?

13. Please rate the auditory tone feature listed below as acceptable/ unacceptable.

	Intensity	Duration	Pitch
Acceptable			
Unacceptable			

14. Did the warning tone interfere with voice communication?

Yes_____ No_____

If yes, please explain.

15. Do you believe that the basic concept of this approach mode alerting system warrants further development?

Yes_____ No_____

Please explain.

16. Was your confidence increased during approaches due to the approach mode?

Yes_____ No_____

Please explain your response.

17. Was the sequence of operation satisfactory for approach mode?

Yes_____ No_____

If no, what changes do you recommend, and why?

18. Was the approach light (blue light on indicator) visible during all ambient light conditions encountered?

	Yes	No
Day		
Night		
Clouds		

If no, please explain.

19. Was your confidence and precision increased during overhead traffic patterns due to AWSS?

	Confidence	Precision
Yes		
No		

If no, please explain.

20. Was the method of operation for approach mode satisfactory for overhead traffic patterns?

Yes_____ No_____

If no, why not?

21. The ranges of altitude (in feet) between the outer and inner trigger levels were:

Just Right_____ Too Large_____ Too Small_____

Please explain why, and state optimum separation.

22. What trigger levels do you consider most suitable for the following flight conditions?

	T_{out}	T_{in}
Climbs and Descents		
Approaches		
Cruise		

23. Were the indicator lights satisfactory for flight operations to include:

Size _____

Shape _____

Color _____

Lighting Brightness _____

If no, please explain.

24. Was the size and location of the remote indicator acceptable?

	Size	Location
Yes		
No		

If no, please explain.

25. Could command altitude and baro setting be easily read?

	Command Altitude	Baro
Yes		
No		

If no, why not?

26. Did the combined tone and flashing light aid you during the approach mode?

Yes_____ No_____

Please explain.

27. Could the command altitude be reset quickly enough for all in-flight operations?

Yes_____ No_____

If no, please explain.

28. Did the requirement for being responsible for another barometric setting cause an unacceptable increase in pilot workload?

Yes_____ No_____

If yes, please explain.

29. For night operations please rate the visibility of each of the items below:

a. Flight Command Indicator

	Satisfactory	Too Dim	Too Bright
Descent Light			
Approach Light			
Confirm Light			
Climb Light			

b. AWSS Control Panel

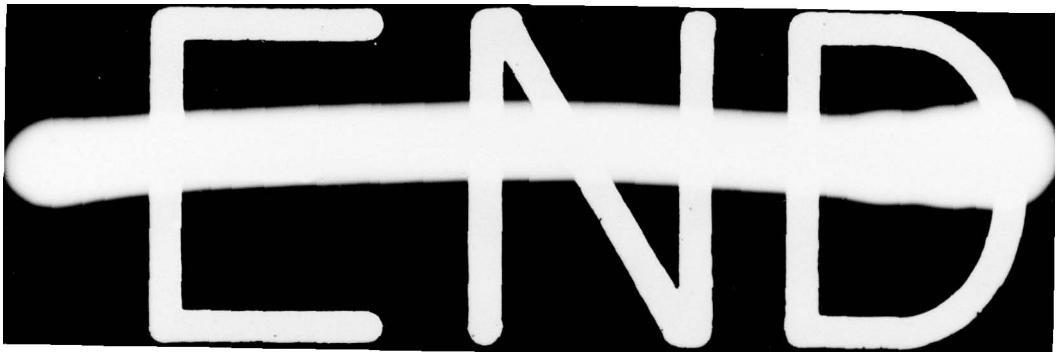
	Satisfactory	Too Dim	Too Bright
Command Alt Window			
Baro Alt Window			
AP Button (when on)			

30 Even if you do not judge this system to be operationally satisfactory, do you believe the basic concept of an altitude alerting system warrants further development?

Yes_____ No_____

31. What specific recommendations do you have for improvements, additions, deletions, and changes to the AWSS (including operations and display configurations)?

32. Do you believe the AWSS, as flown, is operationally satisfactory for installation in Air Force aircraft, and why or why not?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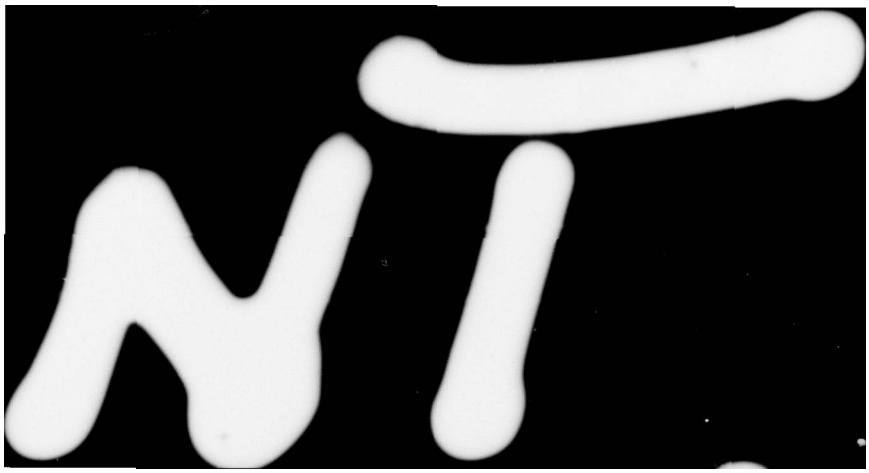

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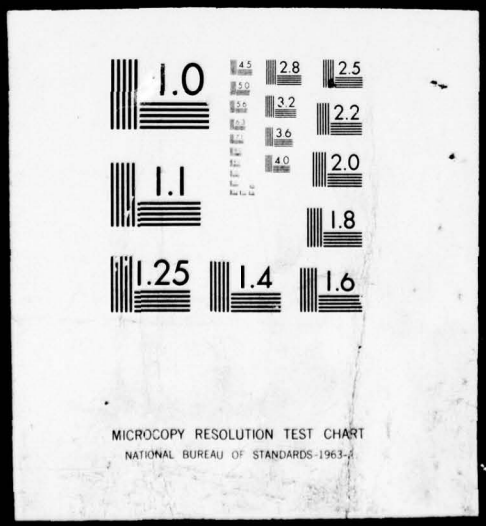

SUPPLEMENTARY

INFORMATION

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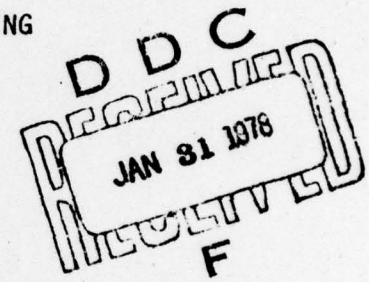

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PROJECT ENGINEERING PSYCHOLOGISTS

DECEMBER 1977

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The subject pilots who were not current in the T-38 aircraft were given a comprehensive briefing on the T-38 front cockpit. This briefing included identification of the major or critical items and components in the front cockpit which were not available in the rear cockpit.

DATA COLLECTION

Each subject pilot was thoroughly debriefed following the test sorties and immediately filled out the appropriate portion of the questionnaire. All pertinent verbal comments made during debriefings were recorded by the project pilot and a transcript was attached to the subject's completed questionnaire. In flight, the project pilot recorded his observations of system accuracy, the subject's comments, and overall commentary regarding subject pilot and system performance.

RESULT AND DISCUSSION

The AWSS evaluation was accomplished to evaluate the changes and improvements made on a Harowe Altitude Warning System. The system was evaluated by USAFIFC/RD in 1974. The findings of the previous evaluation are summarized in IFC report TR 74-7.

During the current evaluation, six (6) of the thirteen (13) subject pilots considered the Harowe AWSS acceptable for installation in Air Force aircraft in its present configuration. Of the six (6) pilots rating the system acceptable, three (3) were currently assigned to tactical aircraft and three (3) were in crew-type aircraft. However, one pilot from each of these groups qualified his acceptance of the system by rating it as acceptable for installation in crew-type aircraft only. Of the seven (7) pilots rating the system unacceptable, two (2) were tactical pilots and five (5) were from crew-type aircraft. Those who thought it was not acceptable felt that the information provided by the system did not justify the increase in workload. Ninety-two percent (92%) of the subject pilots believed the concept of an altitude warning system warranted further development. Seventy-seven percent (77%) of the subject pilots felt that the Harowe AWSS reduced the possibility of altitude misinterpretation, and sixty-two (62%) reported it reduced the possibility of misreading the altimeter. Generally, subject pilots believed that the AWSS served more as a cueing device or reminder to cross-check the altimeter. Sixty-nine percent (69%) of the subject pilots stated that the AWSS did not increase their precision in maintaining command altitude while fifty-four percent (54%) said that it made no difference in their confidence while maintaining command altitude. The majority of the subject pilots reported that their confidence in maintaining an altitude was increased with the system. Using the AWSS, they felt their attention could be diverted from the altimeter for longer periods without fear of exceeding altitude restrictions.

Normal Mode

Twelve (12) of the thirteen (13) subject pilots agreed that two trigger levels were adequate for the profiles flown. The other subject pilot felt there was a need for separate trigger levels for approaches.

Having the capability of changing trigger levels in flight was considered necessary by fifty-four percent (54%) of the pilots. They felt that different phases of flight required different altitude tolerances and that the AWSS should have trigger level change flexibility. However, one of the pilots felt that having changeable trigger levels would increase the chance of error in setting and would therefore increase the pilot's workload. At least half of the subject pilots felt a toggle switch for present trigger levels would be preferable to the present system.

The test sorties were flown with an inner trigger level of 200 feet, and an outer trigger level of 1,000 feet. These trigger levels were found acceptable by the majority of the subject pilots. The span in feet between the inner and outer trigger levels was considered acceptable by eighty-four percent (84%) of the pilots. When asked what trigger levels were considered most suitable for climbs and descents, the majority of the subject pilots responded that 500 feet for the outer and 200 feet for the inner trigger level would be the most acceptable. For cruise type conditions, 200 feet for both the outer and inner levels was felt to be optimum. A trigger level of 100 feet was felt to be more suitable for approaches than the 200 feet level.

The sequence of operation for the normal mode was considered satisfactory by ninety-two percent (92%) of the subject pilots. When asked which signal alerted them first on exceeding the inner trigger level, all the subject pilots stated that it was the audio signal. Intensity and duration of the warning tone was considered acceptable by sixty-four percent (64%) of the subject pilots. Eighty-five percent (85%) of the pilots considered the pitch of the auditory tone acceptable. All of the subject pilots stated that the warning tone did not interfere with voice communications. Six (6) of the pilots felt that the warning tone became distracting in the VFR pattern after several minutes. They felt some type of warning tone cut-out should be included to remove the traffic pattern distraction.

The size, shape, and color of the lights on the remote display unit were considered satisfactory by ninety percent (90%) of the subject pilots. One problem noted was that the remote indicators resembled an angle of attack indexer used in many Air Force aircraft and could lead to possible problems of confusion between the two. The size of the remote indicators was considered acceptable by all of the pilots. For this evaluation, the remote indicators were located on each side of the glare shield. Fifty-four percent (54%) of the pilots considered this location unsatisfactory because they felt it placed them too far to the side to be in the normal field of view. Generally, the pilots felt the indicator lights should be positioned closer to the ADI as this is where the pilot's attention is normally concentrated. One hundred percent (100%) of the pilots reported that the brightness of the remote indicator was unacceptable. The indicators were easily washed out in high ambient light conditions. This was especially true for the green confirm light.

Command altitude and baro setting could be easily read as reported by seventy-seven percent (77%) of the pilots. Sixty-two percent (62%) of the pilots reported that the command altitude could be reset quickly enough for in-flight maneuvers. Several subject pilots felt a slew switch would be an

added value for setting command altitude. Another pilot felt a click stop at each fifty foot altitude would be helpful in setting command altitude. Thirty-eight percent (38%) of the subject pilots experienced some difficulty in resetting the command altitude, especially under high workload conditions.

Requiring the additional baro setting for the AWSS was considered an acceptable increase in workload by fifty-four percent (54%) of the subject pilots. There was a common tendency by the pilots to forget the AWSS baro setting when setting the standard altimeter. Due to the flight characteristics of the T-38 and the flight profile used for this evaluation, the baro setting was required to be reset frequently. This was due to the aircraft passing through the altitude transition level (baro setting 29.92) during numerous occasions throughout the flight profile. One pilot suggested incorporating a transition level switch to automatically set the 29.92 setting into the system when the switch is thrown.

During the investigation of the Harowe AWSS in the overhead traffic pattern, only one subject pilot felt that his confidence and precision was increased using the AWSS. The majority of the pilots found the warning tone to be distracting during the final turn to landing when command altitude remained set to traffic pattern altitude. Only one subject pilot felt that the system aided in maintaining overhead pattern altitude. The same foregoing comments applied generally to the AWSS used in the traffic pattern at night. Although the remote indicators could be seen better at night due to the lower ambient light conditions, they tended to be somewhat more distracting. Due to the aforementioned distractions, fifty-four percent (54%) of the subject pilots felt the normal mode was unacceptable for use in the traffic pattern.

Approach Mode

Ninety-two percent (92%) of the subject pilots believed that the Approach Mode was a worthwhile concept which warranted further development. Seventy percent (70%) of the subject pilots felt the approach mode actually increased their confidence during approaches. The accuracy of the system was considered excellent by the majority of the subject pilots. The subject pilots felt their workload and stress of flying an approach in extremely low weather conditions was greatly reduced by having approach mode of the altitude warning system in operation.

The sequence of operation for the approach mode was considered satisfactory by seventy-seven percent (77%) of the subject pilots. The majority of the subject pilots stated that they were alerted by the tone rather than the remote indicator lights on approaching DH. Again, the subject pilots felt the light level of the remote indicators was too weak to be compatible with all ambient light conditions. Fifty-seven percent (57%) of the subject pilots felt the intensity of the blue approach light was too weak to be visible during normal day lighting conditions. Several subject pilots suggested that the remote indicator light be placed closer to the ADI where they would be in the pilot's primary field of view while flying instrument approaches.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

a. The subject pilots were more or less equally divided in their opinions as to the operational acceptability of the AWSS (as configured and flight evaluated). Half of the subject pilots felt that the information provided by the AWSS did not justify the additional workload. The other half felt that in a crew-type aircraft, the system would be acceptable.

b. The normal mode of operation was acceptable for climb, cruise, and descents. The trigger levels were found to be highly accurate.

c. The approach mode of operation was acceptable in both sequence and accuracy of trigger levels.

d. The AWSS in its present configuration did not lend itself to efficient use in the VFR traffic pattern.

Recommendations:

a. A switch should be placed on the control head to convert the baro setting to 29.92.

b. The brightness of the remote indicator should be increased.

c. The remote indicator lights should be positioned on the instrument panel in close proximity to the primary flight instruments. This would allow them to be integrated into normal instrument cross-check.

d. The remote indicator lights display format should be changed. At present, they could be easily mistaken for the standard AOA indexer.

e. The command altitude set knob should have detents at each 50 foot increment to facilitate setting decision heights and minimum descent altitudes more accurately.

f. The control head should be positioned in a location that can be easily seen and reached by the pilot.